# Tensors and Broadcasting

# Tensors

- D-dimensional arrays of numbers
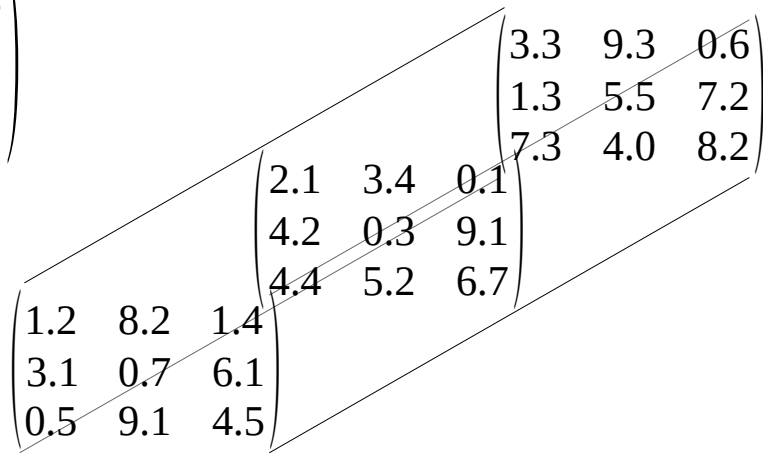
  - Vectors – 1D tensors $\begin{pmatrix} 1.2 \\ 3.1 \\ 0.5 \end{pmatrix}$

  - Matrices – 2D tensors $\begin{pmatrix} 1.2 & 8.2 & 1.4 \\ 3.1 & 0.7 & 6.1 \\ 0.5 & 9.1 & 4.5 \end{pmatrix}$

$$\text{size}(\mathbf{T}) = s_1 \times s_2 \times \cdots \times s_D$$
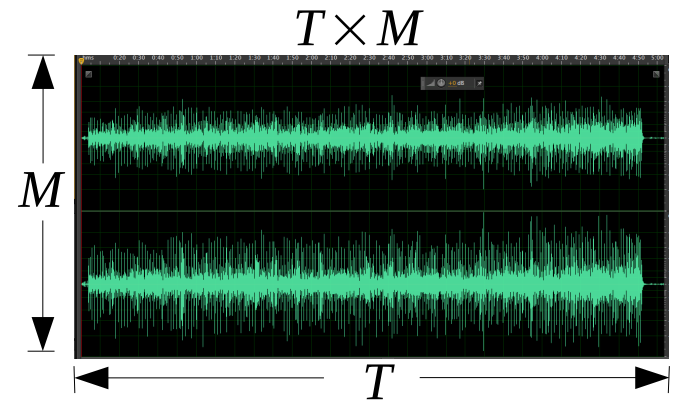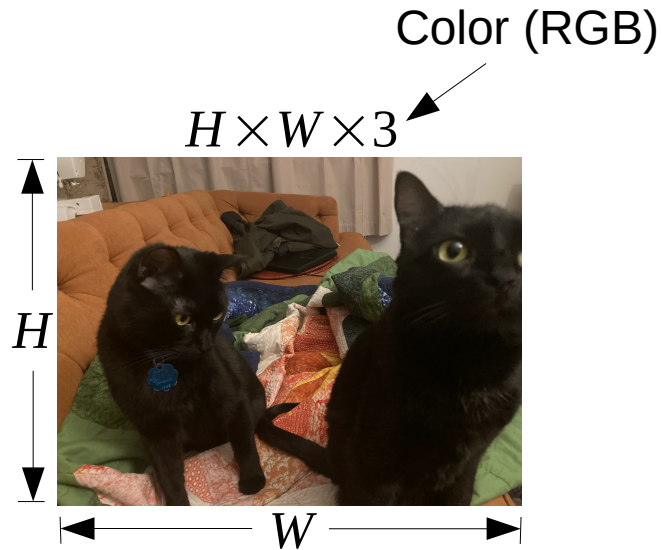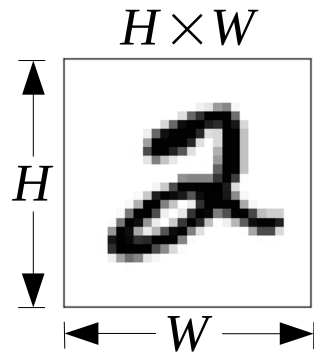$$\dim(\mathbf{T}) = D$$
$$\mathbf{T}_{i_1, i_2, \ldots, i_D}$$

$\begin{pmatrix} 3.3 & 9.3 & 0.6 \\ 1.3 & 5.5 & 7.2 \\ 7.3 & 4.0 & 8.2 \end{pmatrix}$

$\begin{pmatrix} 2.1 & 3.4 & 0.1 \\ 4.2 & 0.3 & 9.1 \\ 4.4 & 5.2 & 6.7 \end{pmatrix}$

$\begin{pmatrix} 1.2 & 8.2 & 1.4 \\ 3.1 & 0.7 & 6.1 \\ 0.5 & 9.1 & 4.5 \end{pmatrix}$

# Tensors as Data

- Some data is naturally multi-dimensional

$H \times W$



$H$

$W$

Color (RGB)

$H \times W \times 3$



$H$

$W$

$T \times M$



$M$

$T$

# Tensors as Parameters

- Parameter: trainable value

Input data (dim = 1)

$$f(x) = W x + b$$

Parameter (dim = 2)  Parameter (dim = 1)